UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/824,719	04/15/2004	Peter J. Schubert	89190.130903/DP-30974-3	6710

7590 05/30/2008

Jimmy L. Funke, Esq.
Delphi Technologies, Inc.
Mail Code 480410202
P.O. Box 5052
Troy, MI 48007

EXAMINER	
CHUO, TONY SHENG HSIANG	

ART UNIT	PAPER NUMBER
1795	

MAIL DATE	DELIVERY MODE
05/30/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/824,719	SCHUBERT ET AL.	
	Examiner	Art Unit	
	Tony Chuo	1795	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *21 March 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-24* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-24* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *01 October 2007* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 3/21/08 has been entered.

Response to Amendment

2. Claims 1-24 are currently pending. Claims 25-37 were previously cancelled. The amended claims do overcome the previously stated 102 and 103 rejections. However, upon further consideration, claims 1-24 are rejected under the following new 103 rejections.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-5, 15, and 19-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711).

The Winstel reference discloses a system for storing and retrieving hydrogen comprising: a housing "4"; a passage connected to the housing for conducting hydrogen gas into and conducting hydrogen gas out of the housing; a plurality of hydrogen storage members "5" enclosed within the housing; an operative valve control means "6"; and implicitly a heating means for discharging hydrogen gas from the housing through the passage (See column 2, lines 63-67, column 3, lines 40-48, and Figure 2). It also discloses coating palladium onto a silicon surface layer (See column 2, lines 52-55).

Examiner's note: The valve "6" and heating means disclosed by Winstel are construed as a control system that is capable of liberating chemisorbed hydrogen atoms from the dangling bond sites and releasing the liberated hydrogen atoms as hydrogen gas.

However, Winstel does not expressly teach a hydrogen storage member comprising a mass of porous silicon having interior and exterior surfaces, wherein at least the interior surfaces have dangling bond sites at which reversible chemisorption of hydrogen atoms occurs; wherein at least the interior surfaces of the porous silicon have dendritic spikes or etched pits; wherein the at least interior surfaces are bare silicon surfaces at which the dangling bond sites are exposed; wherein the porous silicon defines a surface layer over at least a first surface portion of the hydrogen storage member; porous silicon that is in a monocrystalline form; porous silicon that is a silicon

wafer; porous silicon that is a polycrystalline form; porous silicon that is derived from molten silicon by crystallization, or porous silicon that is derived from silicon waste obtained from a silicon process waste stream. The Northrup reference discloses a porous silicon structure that is formed by electrochemically etching a crystalline silicon substrate or wafer "10" with a hydrogen fluoride solution (See column 3, lines 61-64 and column 4, lines 50-52).

Examiner's note: The process of etching the surface of the silicon layer inherently forms interior and exterior surfaces, wherein the interior surfaces of the porous silicon have etched pits and also forms bare silicon surfaces on the interior surfaces. It is also inherent that the porous silicon defines a surface layer over at least a first surface portion of the hydrogen storage member. In addition, as evidenced by Woo et al, the process of wet etching the surface of a silicon film with HF, cleans the surface of the silicon film to form a bare silicon surface such that hydrogen bonds to the surface of the silicon film in dangling bond type (See column 4, lines 20-28). In addition, it is well known in the art that crystalline silicon wafers can be formed in a monocrystalline form or a polycrystalline form. Further, it is noted that claims 23 and 24 are being construed as product-by-process and that the product itself does not depend on the process of making it. Accordingly, in a product-by-process claim, the patentability of a product does not depend on its method of production. The claim is obvious as it has been held similar products claimed in product-by-process limitations are obvious (In re Brown 173 USPQ 685 and In re Fessman 180 USPQ 324, See MPEP 2113: Product-by-Process claims).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel system for storing and retrieving hydrogen to include a hydrogen storage member comprising a mass of porous silicon having interior and exterior surfaces, wherein at least the interior surfaces have dangling bond sites at which reversible chemisorption of hydrogen atoms occurs; wherein at least the interior surfaces of the porous silicon have dendritic spikes or etched pits; wherein the at least interior surfaces are bare silicon surfaces at which the dangling bond sites are exposed; wherein the porous silicon defines a surface layer over at least a first surface portion of the hydrogen storage member; porous silicon that is in a monocrystalline form; porous silicon that is a silicon wafer; porous silicon that is a polycrystalline form; porous silicon that is derived from molten silicon by crystallization, or porous silicon that is derived from silicon waste obtained from a silicon process waste stream in order to utilize a high surface area porous silicon structure that significantly augments the adsorption and desorption of gases (See Abstract).

5. Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711) as applied to claims 1 and 5 above.

However, Winstel as modified by Northrup et al does not expressly teach a percent void volume of the surface layer that is about 50%. However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Northrup porous silicon structures to include a percent void volume of the surface layer that is about 50% because it has been held that the discovery of an

optimum value of a result effective variable in a known process is ordinarily within the skill of the art. *In re Boesch*, 205 USPQ 215 (CCPA 1980). The percent void volume is a result effective variable of increasing the surface area of the porous silicon structure. In addition, there is no evidence of the criticality of the percent void volume.

6. Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711) as applied to claim 6 above, and further in view of Wagner et al (US 5196377).

However, Winstel as modified by Northrup et al does not expressly teach electronic integrated circuits on a second surface portion of the hydrogen storage member. The Wagner reference discloses integrated circuits that are placed inside cavities of a silicon wafer "10" (See column 11, lines 12-16).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Northrup porous silicon structures to include electronic integrated circuits on a second surface portion of the hydrogen storage member in order to utilize well known integrated circuit processing techniques to provide a silicon water-based integrated circuit carrier offering high density packaging with high yield processes. In addition, one skilled in the art could have combined the elements as claimed by known methods with no change in their respective functions, and the combination would have yielded nothing more than predictable results to one of ordinary skill in the art at the time of the invention.

7. Claims 8 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), and further in view of Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711).

The Winstel reference discloses a system for storing and retrieving hydrogen comprising: a housing "4"; a passage connected to the housing for conducting hydrogen gas into and conducting hydrogen gas out of the housing; a hydrogen storage member "5" enclosed within the housing; an operative valve control means "6"; and implicitly a heating means for discharging hydrogen gas from the housing through the passage (See column 2, lines 63-67, column 3, lines 40-48, and Figure 2).

Examiner's note: The valve "6" and heating means disclosed by Winstel are construed as an equivalent structure for liberating chemisorbed hydrogen atoms from the dangling bond sites and releasing the liberated hydrogen atoms as hydrogen gas.

However, Winstel does not expressly teach a hydrogen storage member comprising a porous mesh of silicon columns, wherein the silicon columns are extruded through at least one aperture that is an integral multiple of the lattice spacing of silicon such that the silicon columns have a minimum energy configuration suitable for forming a crystal. The Kornilovich reference teaches a hydrogen storage medium that is made of a large pile of silicon nanowires that are in the shape of a column such that the medium has porosity (See column 3, lines 27-31). Examiner's note: it is noted that claim 11 is being construed as product-by-process and that the product itself does not depend on the process of making it. Accordingly, in a product-by-process claim, the patentability of a product does not depend on its method of production. The claim is

obvious as it has been held similar products claimed in product-by-process limitations are obvious (In re Brown 173 USPQ 685 and In re Fessman 180 USPQ 324, See MPEP 2113: Product-by-Process claims).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel system for storing and retrieving hydrogen to include a hydrogen storage member comprising a porous mesh of silicon columns, wherein the silicon columns are extruded through at least one aperture that is an integral multiple of the lattice spacing of silicon such that the silicon columns have a minimum energy configuration suitable for forming a crystal in order to improve the storage efficiency of the hydrogen storage medium and to allow fast diffusion of gas molecules such as hydrogen.

However, Winstel as modified by Kornilovich does not expressly teach a hydrogen storage member comprising a silicon having surfaces with dangling bond sites at which reversible chemisorption of hydrogen atoms occurs. The Northrup reference discloses a porous silicon structure that is formed by electrochemically etching a crystalline silicon substrate or wafer "10" with a hydrogen fluoride solution (See column 3, lines 61-64 and column 4, lines 50-52). Examiner's note: As evidenced by Woo et al, the process of wet etching the surface of a silicon film with HF, cleans the surface of the silicon film to form a bare silicon surface such that hydrogen bonds to the surface of the silicon film in dangling bond type (See column 2 line 65 to column 3 line 2).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel/Kornilovich system for storing and

retrieving hydrogen to include a hydrogen storage member comprising a silicon having surfaces with dangling bond sites at which reversible chemisorption of hydrogen atoms occurs in order to utilize a high surface area porous silicon structure that significantly augments the adsorption and desorption of gases (See Abstract).

8. Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057), and further in view of Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711) as applied to claim 8 above. In addition, Kornilovich discloses that the storage efficiency of the described medium improves with decreasing nanowire radius and increasing nanowire length (See column 3, lines 31-33).

However, Winstel as modified by Kornilovich and Northrup et al does not expressly teach silicon columns that have an aspect ratio of length to diameter of at least 10. However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup system for storing and retrieving hydrogen to include silicon columns that have an aspect ratio of length to diameter of at least 10 because changes of proportions was held to be obvious (*In re Feilds* 134 USPQ 242 (CCPA 1962)). In addition, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the gas storage medium to include silicon columns that have an aspect ratio of length to diameter of at least 10 in order to improve the storage efficiency of the gas storage medium.

9. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057) and Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711) as applied to claim 8 above, and further in view of Ciszek et al (US 4594229).

However, Winstel as modified by Kornilovich and Northrup et al does not expressly teach silicon columns that are formed by extrusion of molten silicon to have surfaces on the (111) plane. The Ciszek reference teaches the concept of forming a silicon crystal from a silicon melt such that the silicon crystal is oriented in the (111) plane (See column 7, lines 3-9).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup system for storing and retrieving hydrogen to include silicon columns that are formed by extrusion of molten silicon to have surfaces on the (111) plane in order to yield an improvement of the grain size of the resulting silicon crystal.

10. Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057) and Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711) as applied to claim 8 above, and further in view of Majumdar et al (US 2002/0172820). In addition, Kornilovich discloses nanowires that have a diameter of less than about one micrometer and may include cylindrical structures (See column 1, lines 56-60).

However, Winstel as modified by Kornilovich and Northrup does not expressly teach silicon columns that have diameters of about 1 nm. The Majumdar reference

discloses methods of forming nanowire structures with a diameter of approximately 5 nm to approximately 50 nm (See paragraph [0068]).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup system for storing and retrieving hydrogen to include silicon columns that have diameters of about 1 nm in order to improve the storage efficiency of the gas storage medium by increasing the surface area of the silicon columns. In addition, if the range of the prior art and claimed range do not overlap, obviousness may still exist if the ranges are close enough that one would not expect a difference in properties (*In re Woodruff* 16 USPQ 2d 1934 (Fed. Cir. 1990)).

11. Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Kornilovich (US 7135057) and Northrup et al (US 5882496) and Ciszek et al (US 4594229) as applied to claim 10 above, and further in view of Anthony et al (US 6040230).

However, Winstel as modified by Kornilovich, Northrup et al, and Ciszek et al does not expressly teach silicon columns that have roughened surface. The Anthony reference discloses polysilicon structures "306" that etched with oxygen in order to roughen the surface (See column 6, lines 6-10).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Winstel/Kornilovich/Northrup/Ciszek system for storing and retrieving hydrogen to include silicon columns that have roughened

surface in order to enhance the surface area of the silicon columns and further improve the storage efficiency.

12. Claims 16 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Northrup et al (US 5882496) and as evidenced by Woo et al (US 5926711) as applied to claims 1 and 15 above, and further in view of Meinzer (US 5360461).

However, Winstel as modified by Northrup et al does not expressly teach releasing means that is selected from the group consisting of light sources, current sources, voltage sources, and combinations thereof, wherein the releasing means comprises a light emitting diode. The Meinzer reference discloses releasing hydrogen from a hydrogen storage bed optically by transmitting photons by any known means such as direct illumination by a light source "18", wherein light sources may be laser diodes (See column 5, lines 21-27).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute the Winstel/Northrup method of releasing hydrogen with a releasing means that is a light source, wherein the releasing means comprises a light emitting diode because the substitution of one known method for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

13. Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Winstel (US 4265720) in view of Northrup et al (US 5882496) and as evidenced by Woo et al

(US 5926711) as applied to claims 1 and 15 above, and further in view of Meinzer (US 5360461).

However, Winstel as modified by Northrup et al does not expressly teach a light source that emits photon energy at a wavelength of about 660 nanometers. The Meinzer reference discloses releasing hydrogen from a hydrogen storage bed optically by transmitting photons by any known means such as direct illumination by a light source "18", wherein light sources may be laser diodes (See column 5, lines 21-27).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize a light source that emits photon energy at a wavelength of about 660 nanometers as a means for releasing stored hydrogen because there are a finite number of predictable potential solutions to the recognized problem of releasing hydrogen by using a light source and one skilled in the art could have pursued the known potential solutions with a reasonable expectation of success.

Response to Arguments

14. Applicant's arguments filed 3/21/08 have been fully considered but they are not persuasive.

The applicant argues that the fluid adsorption required of Northrup's silicon layer 27 does not require any internal surfaces with a large number of exposed silicon dangling bonds at which chemisorption of hydrogen can occur. As evidenced by Woo et al, the process of wet etching the surface of the silicon inherently forms internal surfaces that are cleaned such that hydrogen bonds to surface of the silicon film in

dangling bond type. It is well known in the art that etching a surface forms pits that inherently have internal surfaces.

The applicant also argues that Winstel discloses hydrogen absorption so it would be contrary to Winstel to introduce porosity in his silicon layer since doing so would reduce the amount of silicon available for hydrogen absorption. The examiner disagrees with this assumption. It is well known in the art that a porous layer has higher surface area as compared to a non-porous layer. Therefore, based on the teachings of Northrup et al, one skilled in the art would know that introducing porosity into the silicon layer would increase the storage capacity of the silicon layer.

The applicant also argues that Kornilovich teaches that the neutral/molecular hydrogen is absorbed by physisorption and not chemisorption as claimed by the applicants. The applicant further argues that the examiner improperly equates Kornilovich's disclosed "silicon nanowire" to applicants' claimed "silicon column" because a nanowire is periodic in one dimension only, and therefore not a crystal. The Kornilovich reference is relied upon for the teaching of a silicon material in the shape of a cylindrical structure and a diameter of less than about one micrometer. The applicant is reminded that claims are given the broadest reasonable interpretation consistent with the specification. Therefore, a "silicon column" is construed as being any silicon material that is in the shape of column. Since the Kornilovich silicon nanowire is in the shape of a column, it reads on the claims. In addition, there is no limitation in claim 8 that requires the silicon column to be crystalline.

The examiner agrees with the applicant's argument that Kornilovich's silicon

nanowire formed by chemical vapor deposition does not inherently have surfaces on the (111) plane. Therefore, the 103 rejection of claim 10 is withdrawn. However, as taught by the Ciszek reference, silicon crystals can be formed such that the silicon crystals are oriented in the [111] plane.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tony Chuo whose telephone number is (571)272-0717. The examiner can normally be reached on M-F, 7:00AM to 3:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Patrick Ryan can be reached on (571) 272-1292. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a

USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

TC

/Jonathan Crepeau/
Primary Examiner, Art Unit 1795